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*Publication date:*  
2014

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Hjortkjær, J. (2014). *The shape of sounds: Audiovisual integration of visual shapes and musical sounds in the human brain*. Poster session presented at The Neurosciences and Music V - Cognitive Stimulation and Rehabilitation, Dijon, France.

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# The Shape of Sounds: Audiovisual integration of visual shapes and musical sounds in the human brain

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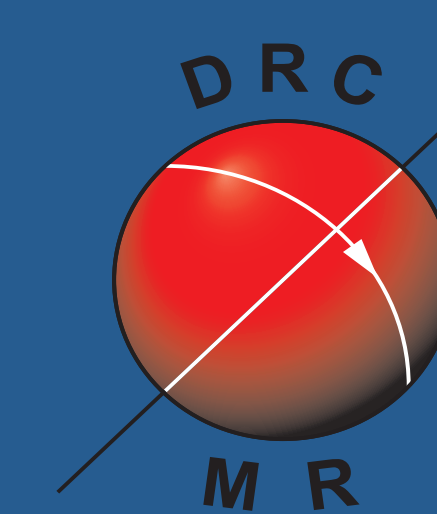
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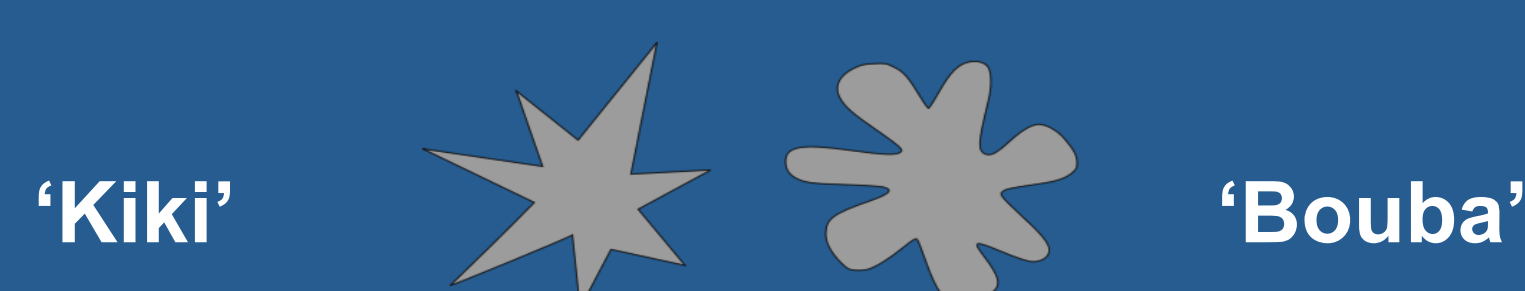
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## Introduction

Humans spontaneously perceive sounds in terms of abstract shape properties. One sound may be heard as 'round' and another as 'sharp'. Such 'sound symbolism' is illustrated in the so-called 'Kiki-Bouba-effect'<sup>(1)</sup>:



What are the neural correlates of these 'synesthesia-like' mappings of shape between vision and sound in the normal brain?

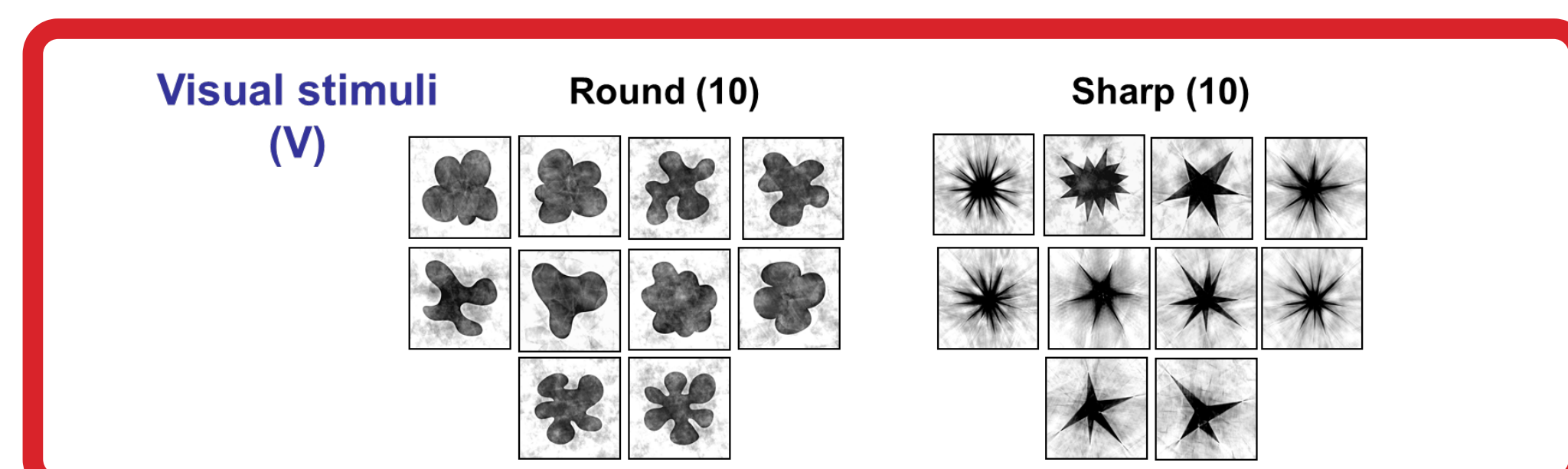
## Methods

### Participants:

24 healthy adults (23 ± 4.1 y.o. (18-35), right-handed)

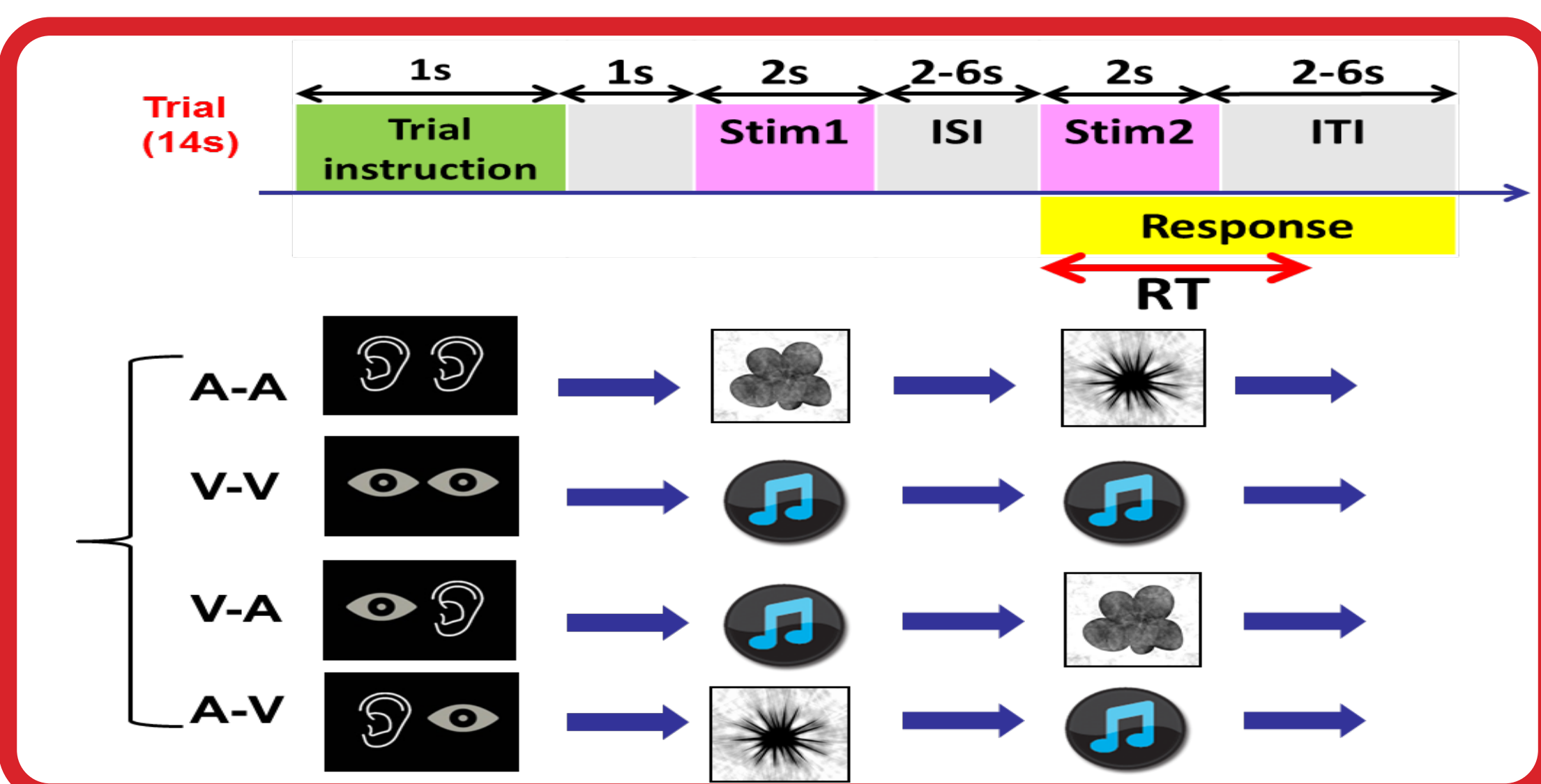
### Stimuli

Visual stimuli consisted of abstract rounded or spiky 2D figures matched with respect to their global spectral properties. Electronic musicians created sounds (2s) to match the 'shape' of the images.



### Event-related fMRI experimental paradigm

Two stimuli (S1-S2) were presented sequentially in each trial. Stimuli were either auditory (A) or visual (V), and either congruent (c) or incongruent (i) yielding 8 conditions (AAc, AAi, VVc, VVi, VAc, VAi, AVc, AVi).



### fMRI acquisition:

Fast gradient echo EPI sequence, TR=2490ms, TE=30ms, 42 axial slices (FOV 192mm, 3 x 3 x 3 mm<sup>3</sup>), whole-brain coverage

### Data analysis

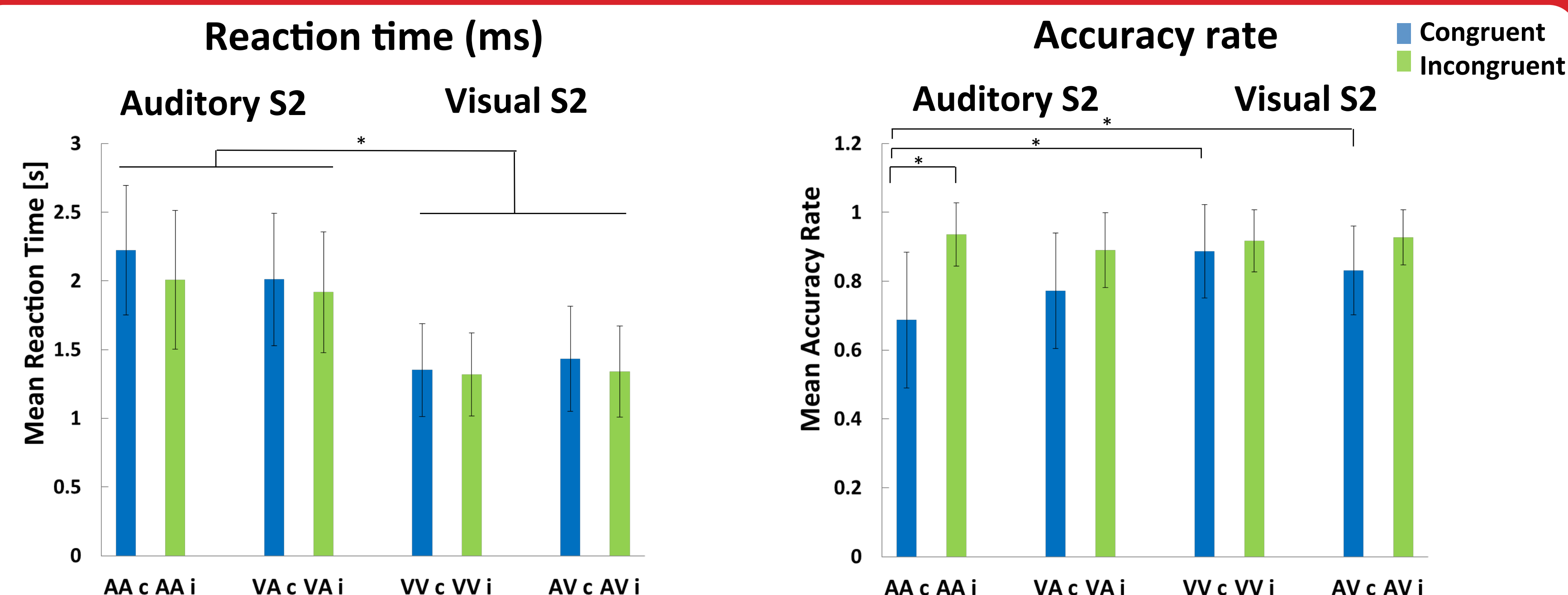
Behavioral data: 3-way repeated-measures ANOVA and Turkey's HSD post-hoc test.

fMRI: general linear model with separate regressors for S1 and S2 within each trial condition. Group level: factorial 2x2x2 model with factors S2-Modality x Congruency x Sensory-Matching.

## Results

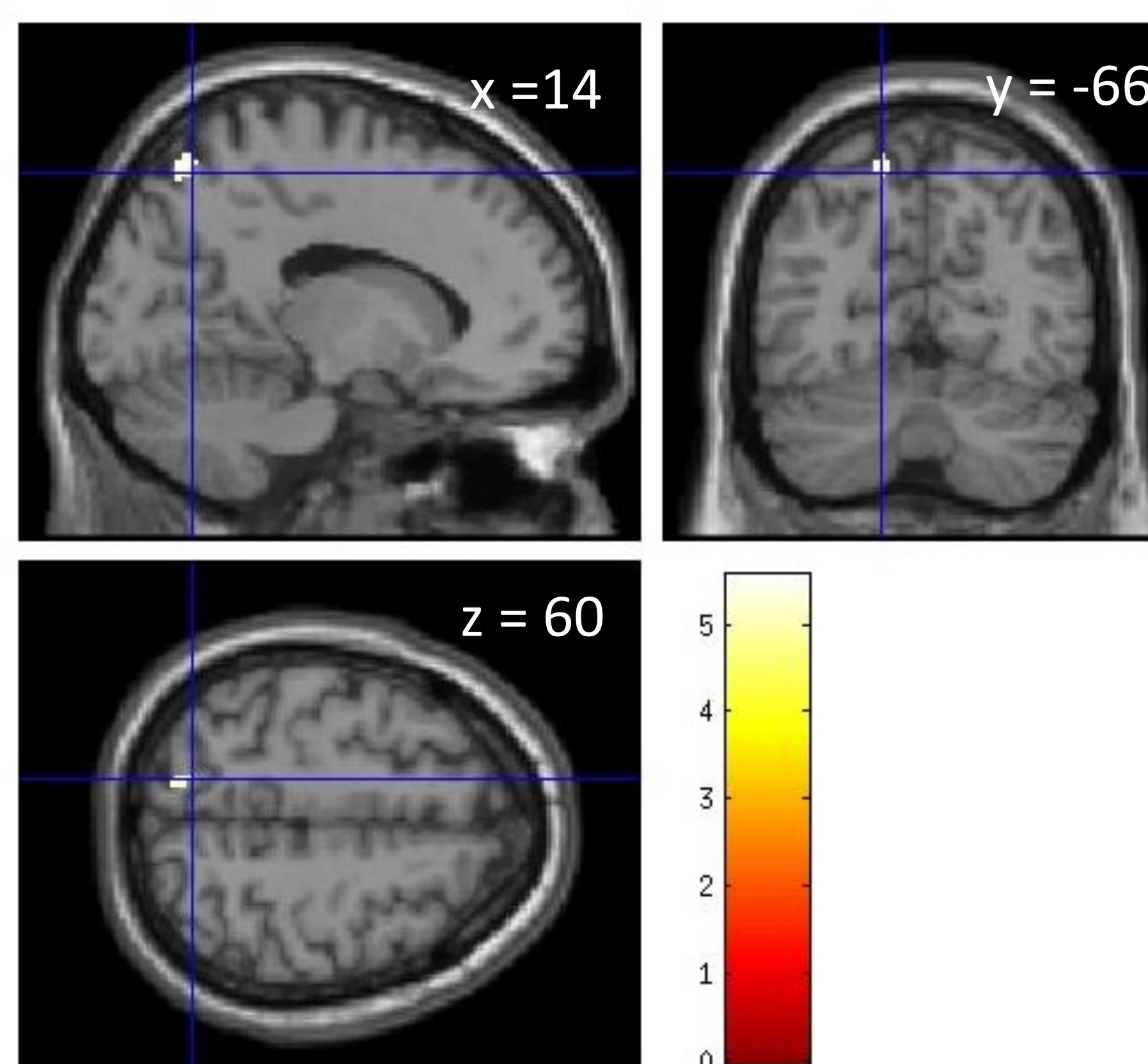
### Task performance

\*Tukey's HSD post-hoc test  $P < 0.01$



### fMRI

$[(VA\ c + AV\ c) > (AA\ c + VV\ c)] > [(VA\ i + VA\ i) > (AA\ i + VV\ i)]$



Increased activity in the medial part of the left posterior superior parietal lobe (pSPL) for congruent shapes when these are matched across visual and auditory modality. Activity related to the incongruity of shape information was observed in the right superior and inferior frontal gyri (SFG/IFG) and in left inferior parietal lobe (IPL).

**Figure 1:** Effect of the interaction Sensory-Matching by Congruency (congruent > incongruent x bimodal > unimodal) (FWE  $P < 0.05$ )

## Discussion

- Increased left-lateralized activation of pSPL in bimodal relative to unimodal matching for congruent opposed to incongruent stimulus pairs.
- SPL is known to be involved in switching attention between auditory and visual information<sup>(2)</sup>, and in attending to visual shapes<sup>(3)</sup>. Our results suggest that the posterior part of SPL may be involved in binding abstract shape information across modalities.

## Conclusion

Posterior SPL plays a role in audio-visual integration of abstract visual shapes and musical sounds

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